GRADE LEVEL: 6-8 | TIME REQUIREMENT: 4 HOURS

CHEMISTRY: ELEMENTS AND THE PERIODIC TABLE

1 READING | 3 ACTIVITIES

INTRODUCTION

If you refer to the Adopt-Adapt-Apply model, most innovations are of the **Adapt** kind in that they take something and modify it for a new purpose, or they improve it to better fulfill its original purpose. Very few innovations are of the **Apply** kind—where pure science and basic facts are developed into a technology. **Apply** innovations are very exciting because they are often some of the most ground-breaking and furthest-reaching innovations.

The Manhattan Project represents an example of an **Apply** innovation. The basic knowledge of how atoms are structured and of what makes something one element and not another, all culminated in an investigation in a Berlin lab in 1938. That basic knowledge, combined with the discovery of a new element seven years and countless hours of work later, unlocked the secret of atomic energy and atomic weapons.

The Manhattan Project succeeded because of the work of some of the best scientists in the world, but it also took huge investments by two Allied countries, as well as lots of work from civilians and military personnel who had no idea what they were working on. The Manhattan Project at once represented a pinnacle of human scientific achievement, but also a led to a new era of fear and danger.

Many scientists were uncomfortable with what they had accomplished, and those results certainly changed the world forever, in profound ways.

OBJECTIVE

Together these resources introduce students to the basis of chemical diversity—the periodic table and nuclear structure. They start with historical context, describing the Manhattan Project and its race to understand and control fission. Then they have students explore the periodic table and nuclear structures, looking at patterns and building models. Electrons are not explicitly discussed, because the phenomena discussed have to do with nuclear physics and chemistry. But you could easily add in electrons if you need to.

STANDARDS

NGSS DCI PS1.A
Structure and Properties of Matter

NGSS DCI PS3.A
Definitions of Energy

NGSS DCI ETS2
Links Among Engineering, Technology, Science, and Society

NGSS SEP
Developing and Using Models

NGSS CCC
Structure and Function

NGSS CCC
Energy and Matter

PERFORMANCE EXPECTATIONS

NGSS DCI MS-PS1-1
Develop models to describe the atomic composition of simple molecules and extended structures.

NGSS DCI MS-PS1-3
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

READING (1)

1. BIG SCIENCE

Description
This reading introduces the context for the rest of the unit and outlines for students the problem of understanding how to manipulate elements. Have students discuss what it might have been like to work in the Manhattan Project as a scientist. There are some great video selections on the Real World Science website to flesh out this reading.

ACTIVITIES (3)

1. BUILD A TABLE

Description
In this activity students will have the information about all the elements known when Mendeleev developed the first Periodic Table. Have the students work in structured groups to organize the elements based on their characteristics. If the students have learned already about the periodic table, you might find that they are trying to reproduce it here. Any form of organization is acceptable, as long as there is group consensus on the organization and group members can justify that choice based on characteristics of the atoms.

Supplies
A set of Element cards for each group

Instructions
Set up groups using your strongest Kagan structures or other cooperative learning methods to make sure groups reach consensus and everyone participates. Explain what the information on each card means, and ask the students to arrange the cards in a structure that makes sense to them. Be sure to have groups present to the whole class their organization and thinking so that they can see alternate ways of organizing the elements.

2. BUILD AN ATOM

Description
Students will use periodic tables to build small atomic nuclei. Then they will look at models you provide of larger atoms to identify them based on the number of particles they contain. If you want, you can use these models as a base for exploring electrons and ions. Since electrons and ions were largely irrelevant to the nuclear physics at the heart of the Manhattan Project, these activities don't focus on those aspects of atoms, but can be easily added.

Supplies (for each group)
3 Containers (small mason jars or pill bottles will work)
1 Cup each of 2 kinds of dried beans
1 Periodic table

Instructions
To make the best model, the two kinds of beans should be similar in size but different in color—kidney beans and pinto beans or black beans, for example. If you want to extend your model to electrons, you can use lentils or another small bean.

Each group will make a model of three small elements and will fill in the responses to the prompts. Then you will give students some atomic models, and they will count the parts of the models and use a periodic table to identify them. For these unknowns, pick smaller atoms like sodium and chlorine. You could make one different unknown for each group and then have the groups trade unknowns.

3. BUILD AN ISOTOPE

Description
This activity follows naturally from the previous. In building and discussing models of isotopes, students will naturally analyze what makes an atom one element and not another. The activity also gets students to look at what makes some nuclei less stable than others.

Supplies
(The same supplies used in Build an Atom)
Corn puffs, extra beans, salad spinner (optional)

Instructions
If you do this activity immediately following Build an Atom, students can just modify the models they have already built. After they make their own isotopes, you will show them the isotopes of Uranium and a Plutonium model. The main objective of this is to get students to see how comparatively large the nuclei of these elements are and how small the difference in physical characteristics between isotopes is. If you wish, you can demonstrate how centrifuges are used to separate isotopes. Put kidney beans and corn puff cereal inside a salad-spinner. When you spin this kitchen centrifuge, you will see that the beans tend to go to the outside and the cereal to the inside. However, the difference in mass is small, so it is still hard to separate the mixture. Such differences are why the Manhattan Project had so much trouble getting enough Uranium 235 to make an atomic bomb.

ADDITIONAL RESOURCES

To accompany these activities, try these books:

+ *Bomb: The Race to Build—and Steal—the World's Most Dangerous Weapon* by Steve Scheinken, Square Fish 2018 (middle school, fiction).
+ Trinity: A *Graphic History of the First Atomic Bomb* by Jonathon Fetter Vorm, Hill and Wang, 2013 (middle and high school, graphic non-fiction).

ACTIVITY

BUILD AN ISOTOPE

INTRODUCTION

Isotopes are forms of elements with different numbers of neutrons. Scientists can use isotopes for many purposes, including to find out how old a bone is or how cold it was when a glacier was formed. An isotope is represented by the Atomic Symbol followed by the number of neutrons in the isotope. For example, U235 is the form of uranium scientists were trying to isolate in the Manhattan Project.

Your teacher will give you three containers representing models of three elements—hydrogen, carbon, and oxygen.

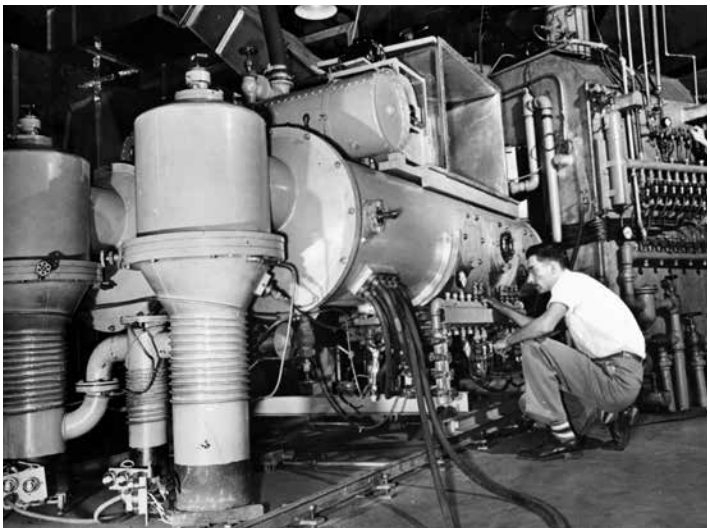
You are going to modify these models to make isotopes of each element. To make an isotope, you will change the number of neutrons in the model. Make the most common isotope of each element: for hydrogen, that is H2; for carbon, that is C14; and for oxygen, that is O16.

In the Manhattan Project, scientists were trying to isolate enough of the specific isotope of uranium they needed to construct what would be the first atomic bomb. The most common isotope of uranium is U238. The isotope needed in the Manhattan Project was U235. U235 is only 0.72 percent of all uranium.

At first, Manhattan Project scientists tried to get enough U235 by separating atoms by the difference in their mass. That, as you can imagine, is very hard, and some very special kinds of centrifuges had to be used. In the end, scientists made only enough U235 for one bomb.

Along the way, Manhattan Project scientists discovered that when U238 is hit by a fast neutron, it becomes a different element—plutonium. It was easier to make plutonium than to get U235, and it takes less plutonium than uranium to make a bomb. By the summer of 1945, Manhattan Project planners had made a large reactor that produced enough plutonium for the cores of three bombs. One of these plutonium bombs was used for testing in what would be called the Trinity Test. Another was used in the war against Japan. The third was used for research.

Your teacher will show you models of uranium and plutonium atoms.



Technicians working on a cyclotron built to create radioactive phosphorus, in St Louis, Missouri, in 1945.
(Image: The National WWII Museum, 2012.019.501.)

NAME: **DATE:**

1. **Just by looking, can you tell the difference between model C and O atoms? Does one model look like it has more beans (protons and neutrons) than the other? Do you think the models have different weights?**

2. **What about the difference between O16 and O18? Can you tell these models apart?**

3. **Your teacher will give you models of U238 and U235, and of plutonium.**

   Can you tell the difference between the model isotopes by looking at them?

   What about between plutonium and uranium?

4. **Is there another way you could find the difference between these isotopes? Without opening the models and counting? Brainstorm an idea and describe your method in the space below:**